[FOR THE USE OF MEMBERS.]

Royal Institution of Great Britain.

1851.

WEEKLY EVENING MEETING,

Friday, March 28.

William Pole, Esq. M.A. F.R.S. Treasurer, in the Chair.

Nevil Story Maskelyne, Esq., M.A.

On the Connexion of Chemical Forces with the Polarization of Light.

Any facts which can throw light upon the ultimate molecular structure and condition of chemical compounds, cannot fail of possessing interest of a high character, as well for those whose thoughts only casually dwell upon questions of physical science, as for the mathematician and the chemist. To the mathematician, indeed, they would, if completely unfolded, supply the data for him to undertake the resolution of the questions of chemical combination and chemical change, by treating them as problems involving the action of mechanical laws; to the chemist, the acquisition of such knowledge would be the removal of some of the profoundest difficulties of his philosophy: but such knowledge is only to be sought in the most difficult paths of the whole range of science. The question of the connexion of chemical type with crystalline form, the fruitful cause of so much contention among mineralogists as to the questions of mineral species, is one on which we have no complete and sure knowledge; for the facts of dimorphism show, that implicated with this question are the actions of other forces, such as electric condition, and above all the mysterious molecular alterations induced by heat. Another direction in which such inquiries have been pursued, has been in tracing the phenomena resulting from the property possessed by many bodies, of modifying a plane-polarized ray of light, by what is termed circular-polarization. This property, from its being proved to be, in a large number of cases, an expression of the *molecular* structure of the substance, and as such inseparable in many cases from its chemical existence, may be taken, whenever this can be shown to be the case, as an evidence of its individuality, and may be used to determine the question of the permanency or transitory character of the molecular type of the substance. The information thus gained may be but vaguely defined, and the truth but darkly seen, yet does it nevertheless afford a valuable and interesting point of view for studying the molecular nature of bodies.

M. Biot has been for forty years enriching chemico-physical science by a series of memoirs detailing the results of his study of these phenomena. He has there shown the value of this means of tracing changes in chemico-molecular constitution.

M. Pasteur has carried forward this inquiry into a new channel by tracing a connexion between this property in substances, of circularly polarizing light, and their crystalline character.

But as it would be impossible to explain the nature of his investigations, or their results, without a preliminary knowledge of the meaning of the terms "circular polarization," and "hemihedrism," it was necessary first to enter a little upon the explanation of them.

Accordingly a ray was explained as being a direction of light, having no relations to space which differed from each other in directions perpendicular to its length. Thus without complicating the subject, by using the language of the beautiful wave-theory, a ray might be imagined as a cylinder of minutest diameter but indefinite length. When such a ray is reflected at a certain angle from glass or such like substance it is split into two; one going into, and through the glass if it be not opaque, the other being reflected from it. These two rays no longer possess the same "absence of sides" as the original ray. For the one has been as it were flattened down to a "strip," while the other has also been flattened similarly into a "strip," but the latter strip is at right angles in regard to its "flattened plane" to what the other is. A similar bifurcation of the ray is produced in the interior of what are called doubly refracting crystals. This bifurcation and flattening of the ray is termed "plane polarization" of it; and it is so far a true instance of polarity—as that the two rays have equal and similar properties in opposed directions.

This was exhibited by the Lime-light. The double image of a small round hole formed by a crystal of Iceland spar was thrown on a screen, and each beam shown to be most capable of reflection in a plane in which the other was incapable of being reflected at all. The action of the tourmaline as a doubly refracting crystal which absorbs one of the rays was then explained; and it was shown that the position of the tourmaline in which it intercepted one ray entirely, was exactly the position in which it gave the other ray free passage. The optic axis of a crystal was then defined to be a direction in it along which the light could pass through the crystal without undergoing any change whatever. The central ray of a polarized beam of light, traversing a piece of calc spar along its optic axis, was shown to be intercepted or transmitted by a tourmaline, precisely as if the section of the crystal of calc spar were away.

An exception was however stated to exist to this law of the neutrality of the optic axis. When a section of quartz, cut so that the beam could career along its optic axis, was put in the path of the polarized ray, it was found that instead of permitting the ray to be eclipsed by the tourmaline when this was placed in the position to eclipse it, that ray on the contrary fell on the screen endowed with beautiful colour; and furthermore that the revolution of the tourmaline induced the most brilliant succession of colours, in the order, in the instance exhibited, of red, plum-colour, blue, green, orange, red. It was shown, however, that another specimen exhibited these colours in the reverse order of red, orange, green, blue, plum-colour, red; in which order the former specimen of quartz produced these colours when the tourmaline was turned in the *opposite* direction. Hence these are termed right and left handed polarizations. The whole of these phenomena were attributed to a complicated set of movements of the light within the crystal, the *resultant* of which was practically a rotation of the plane in which the ray was capable of being reflected,— so that the thicker the crystal, the further round the tourmaline had to be turned to permit the ray to pass it, or to be eclipsed, as the case might be. The opposite order of the colours was explained by the fiction of supposing the one to be the effect of a left handed thread to the screw and the other of a right handed thread characterizing the spiral in which the plane of polarization was supposed to rotate. Of course this was only a popular way of explaining the phenomenon, it being really due to a more complicated series of movements which were explained by Fresnel in the most triumphant manner by the wave theory.

The colour was accounted for by the idea of the red following a longer spiral (having a coarser thread to the screw) than that of the orange, this than the yellow, and so on up to the violet. Without the tourmaline in front all would emerge and form white light; but the tourmaline only allows such rays to pass it as are capable of passing it in its particular position; *i. e.* only such, the rotation of whose plane has brought them round to the position of the plane in which the tourmaline lets the light through.

The singular fact of amethyst being a combination of alternate layers of right and left-handed quartz was then exhibited, both by throwing the image of the alternate layers on the screen, and afterwards by showing that the general effect of a traversing polarizing beam was to produce a neutrality of action. Other substances, however, produce phenomena of circular polarization. Uncrystallized, fused tartaric acid, and barley sugar, &c. produce them; and these bodies when dissolved, and many more in the form of liquids also, do so, some of which were exhibited. But the silica of which quartz consists entirely loses this property when divested of its crystalline character, whether artificially or in its natural state as calcedony, opal, &c. All other bodies retain it so long as their chemical molecule retains its individuality of character.

The next point to be made clear, was the meaning of that form of crystallographic developement called "Hemihedrism." Haüy's great law was, that similar edges or angles were always similarly modified. The nature of similarity in edges or angles was then pointed out, and the general idea of many crystallographers of a sort of nucleus or primitive form existing on which the crystal was formed, was explained, as also the nature of the developement of such a crystal by the modifications placed on the edges and angles according to the law before mentioned. But the exception to that law was not less remarkable for its generality of character than the law itself. This exception consists in the fact that very often crystals are found in which not every similar edge or angle was modified, but where every *alternate* similar edge or *alternate* similar angle was so. This circumstance was then illustrated by the actual truncation of some models; and it was shown that such alternately developed or *hemihedral* crystals may be *right* and *left*, the upper terminal modification being to the right in the one case, and the corresponding and similar lower terminal modification being then to the left, while in the other case they are exactly the converse. Hence, one crystal is, as Pasteur describes it, "*non superposable*" to the other; the one is as the image of the other reflected in a mirror, as the right hand is compared to the left.

A beautiful connexion was then pointed out, as established long ago by the acute observation of Sir J. Herschel, that the plagiedral facettes of quartz indicated, by their relative positions on the crystal, the direction in which the crystal would rotate the plane of polarization. The crystallographic character of these facettes was then pointed out, and their connexion shown with this hemihedrism. But the most beautiful instance of the connexion of hemihedrism in crystals with the direction of the rotatory power of the substance of which they are composed is afforded by the recent discoveries of Pasteur, which may now be almost traced to a law, enunciated thus: that where a substance is hemihedric when crystallized, and possesses the rotating character, the direction of the rotation is indicated by the nature of the hemihedrism.

Paratartaric acid was then introduced. It was described as extremely like tartaric acid in its chemical reactions and identical with it in composition. It was similarly formed to the latter, and was found only one year in the cream of tartar of the wine of the Vosges. Pasteur separated the crystals of the Paratartrate of soda and ammonia into two several sets; the one set he showed to be hemihedric to the right, the other set to the left. The former proved to be the salt of an acid rotating to the right, the latter of one rotating to the left. On examining these acids they were found in every single property, but this rotation, identical with one another and with tartaric acid. Yet when mixed they formed again the Paratartaric acid, which, like the amethyst, is without any action of a rotatory character, and the difference of which from the other two acids was then exhibited by the precipitation by the latter of a salt of lime which did not render either of the former turbid.

Mr. Maskelyne then detailed the experiments of M. Pasteur on malic and aspartic acids and asparagine, and showed how all of these could be understood to contain chemically a molecular unit common to all these and perhaps to tartaric acid, and only modified a little by the super-position as it were of other substances, in combination with it, upon the extremities of its molecule.

He also dwelt on the possibility of the Paratartaric acid being a quadribasic as the tartaric acid is a bibasic acid; it being on this view a conjugate acid consisting of the two united tartaric acids. He then invited attention to the interesting nature of M. Biot's investigation of the action of tartaric acid in solution in water, and he showed that here the acid must be supposed capable of combining with an indefinite or indeed an infinite amount of water, while in other cases again, bodies (such as sugar for instance) exercise no effect upon the water and do not seem to *combine* with, but only to be dissolved in it. The former is an instance of a *continuous* and not *intermittent* sort of combination; and though we need not anticipate a recurrence of the controversy of Berthollet and Proust, yet this shows us that the actions of quantity or mass so dwelt on by the former are not without a great significance; and that the power that can thus enable us to determine such important points in chemical statics, is well worthy of the attention of the philosophic mind.

Dr. Bence Jones permitted a Saccharimeter apparatus of Soleil's, on the double-quartz-plate principle, to be exhibited, and explained its use. Mr. Tennant also exhibited a mass of quite transparent Iceland spar, and a beautiful crystal of plagiedral quartz.

Since the delivery of the lecture, a letter has been received from M. Pasteur stating that he had forwarded for exhibition at and illustration of this lecture, all the finest specimens of the crystals which he has produced, which are further illustrated by models and diagrams. They are the same as those which were exhibited at the Academy of Sciences at Paris, and the liberality of M. Pasteur's act will be appreciated by Members of the Royal Institution, when they are reminded that the Paratartaric acid of which they are the products is impossible to be obtained, from its having only once been accidentally formed, and that these specimens therefore consist probably of the only large accumulation of this body in existence. As soon as they arrive they will be exhibited to the Members.

NEVIL STORY MASKELYNE.

In the Library were exhibited:—

An Apparatus exhibiting the colours produced by Polarized Light, [by Mr. Newman].

Specimens of Pyramidal Alum Crystals, Metallic Arsenic from California, Chrome alum crystals — Nitrate of Potash — Tincal or Native Borax, and Metallic Antimony [by the Pharmaceutical Society].

Sanskrit MSS. — Ancient Pictures of Akbar and his Court, and Jehangír and his Court [by the Royal Asiatic Society].

Models and Diagrams to illustrate a New Theory of Naval Architecture [by Mr. W. E. Hall].

WEEKLY EVENING MEETING,

Friday, April 4.

H. R. H. PRINCE ALBERT, Vice Patron, in the Chair.

SIR CHARLES LYELL,

On Impressions of Rain-drops in Ancient and Modern Strata.

FOOT-PRINTS of reptiles and birds have been observed on the surface of several ancient strata, accompanied by cracks resulting from the shrinkage of mud during desiccation, and it had been fairly inferred that the rocks bearing these marks must have been formed on a beach, between the level of high and low tide. It might therefore have been presumed that the same combination of circumstances would favour the preservation of impressions left by rain-drops, if any rain had fallen on the surface of the same strata, when in a state of mud or sand. Accordingly, memorials of rain have been met with, and Sir Charles Lyell exhibited specimens of fossil rain and hail-prints, collected by Mr. Redfield of New York, from the New Red Sandstone of triassic age in New Jersey, and others of still older date, obtained by Mr. Richard Brown, from green slabs and sandstones of the Coal Measures of Cape Breton in Nova Scotia.

Casts of rain-drops were first recognized in 1828 by Dr. Buckland on the lower surfaces of slabs of quartzose sandstone, found by Mr. Cunningham in the Storeton Hill quarries in Cheshire, where they are accompanied by shrinkage cracks, foot-prints of Cheirotherium, and ripple marks. Mr. Redfield and Sir C. Lyell observed others at Newark in New Jersey in 1841, in red sandstone and shale; and still finer examples have been since met with at Pompton, in the same state, twenty-five miles from New York, by Mr. Redfield. The Lecturer had also an opportunity of observing, in 1842, that a shower of rain had left numerous impressions on the mud-flats exposed at low water, in estuaries communicating with the Bay of Fundy; and he afterwards obtained a collection of specimens of the hardened mud from Dr. Webster of Kentville, some of which are marked by the drops of a heavy but transient shower which fell on the 21st of July, 1849. The average size of the hemispherical cavities is small, but some of them are no less than half an inch in diameter. Many of them are circular, but in some the longest diameter exceeds the shortest by $\frac{1}{5}$th, or even $\frac{1}{3}$rd. They are surrounded by a small rim of mud, consisting of the matter which has been forcibly expelled from the pit by the falling drop; and this marginal rim sometimes projects as much above the plane of the stratum, as the bottom of the pit ex-